DOCUMENT RESUME

ED 301 181 IR 013 521

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TITLE The Computer in Education: An Investigation of Research Dealing with Maximizing Achievement with CAI.
INSTITUTION Indiana Univ., South Bend. Div. of Education.
PUB DATE 4 Apr 88
NOTE 39p.
PUB TYPE Information Analyses (070) -- Reference Materials - Bibliographies (131)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; Annotated Bibliographies; *Cognitive Style; *Computer Assisted Instruction; Computer Literacy; *Computer Software; Elementary Secondary Education; Higher Education; *Instructional Effectiveness; Microcomputers; Program Implementation; *Student Attitudes; Use Studies

ABSTRACT

This study examines the literature in order to evaluate the use of microcomputers as educational tools in the classroom from kindergarten through the college level. Following a brief introduction, annotations for 38 articles are provided under the following topic headings: background articles containing statistics and examples of computer use; effectiveness of computer-assisted instruction (CAI) on both student performance and their attitudes; implementation of CAI; and making software effective. Three questions are addressed in a discussion of the findings of the research projects described in the annotations: (1) whether the computer is an effective educational tool; (2) if so, how it can best be integrated into the curriculum; and (3) which types of software and learning styles are the most effective for use with computer education. It is concluded that schools need to carefully select, purchase, and use educationally sound software, and that better software needs to be developed for educational purposes. A need for more quality research both on the effects of CAI and the successful implementation of computer education programs in the schools is noted. (42 references) (EW)

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The Computer in Education: An investigation of research dealing with maximizing achievement with CAI.

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April 4, 1988

Presented for S590
to; **Dr. Duvall**

IR013531

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Introduction:

Microcomputers have become an accepted part of our society. There is a need to train students in the use of computers. The National Council of Teachers of Mathematics has said, "computer literacy is an essential outcome of contemporary education. Each student should acquire an understanding of the versatility and limitations of the computer through first hand experience in a variety of fields." (Naisbitt, 1984, pg. 27) In the future most jobs will require a working knowledge of the computer. The place to start the training is in the schools.

Schools have access to an adequate amount of computer hardware. A recent survey indicated that in 1985 over 99% of the schools in the United States had at least one microcomputer. The number of microcomputers in schools has grown geometrically over the past twenty years. In 1981 there were only 127,000 microcomputers in the schools. By 1985 the number of microcomputers had grown to 1,275,000. It is predicted that by 1990 there will be 4,872,000 microcomputers in the schools (D.A.W. 1985). A survey indicated that over half of the states had a state-wide policy requiring students to take a computer literacy course, of the others all encouraged local districts to adopt a policy requiring a computer literacy course (Reinhold and Corket, 1985). With the large number of computers in the schools today, computer education has become a practical option for most teachers.

In the future many jobs will require knowledge of the computer. The U.S. Department of Labor predicted that from 1982 to 1995 the number of jobs for programmers would increase by 77%.

Over the same time interval jobs for systems analysts will increase by 85% (Arndt, 1985). By 1990 over 75% of available jobs in the U.S. will require a working knowledge of the computer (Naisbitt, 1984, pg 27). The proper place to begin the training is in the schools.

The U.S. is not a pioneer in the field of computer education. Many corporations and countries encourage the use of computers to aid in education. In 1984 the Soviet Union adopted a national policy requiring all students to take a computer literacy course. The legislation also called for the use of 1,000,000 computers in their schools by 1990 (Hoot, 1987). A survey of schools in the United Kingdom indicated that each school had at least one microcomputer in use (Whiting, 1985). Many large corporations have made use of the computer to train employees (Wehrenberg, 1985). Computer education is being applied in variety of situations. Computer education is a reality in today's schools.

Glossary:

Computer Assisted Instruction (CAI): The use of the computer to aid in instruction. Can take many forms, for example, drill and practice, tutorials, word processing, data management, etc..

Computer Graphics : Displays of pictures or graphs on the computer screen.

Computer Science : The field dealing with the technical aspects of the computer. Generally deals with programming or computer hardware.

Computer Literacy : The basic knowledge of operating a computer. Generally includes knowledge of how to store and retrieve files, how to print, and a basic understanding of how a computer operates.

Correlation : A measure of the linear relationship between variables.

Drill and Practice : Programs designed to aid a student in practicing a previously learned skill.

Hardware : Machines, devices, and physical equipment used to process data.

LOGO : An educationally based programming language. The language allows for people with no programming experience to perform many tasks with simple programming instructions.

Mainframe : The computer itself, the central processing unit. Generally used to refer to a computer unit that can be accessed by several users at any given time.

Microcomputer : A self-contained computer unit, accessible to one person at a time. Often called a personal computer.

Personal Computer : See microcomputer.

Programming : The process of interpreting human languages to computer languages. Many forms available.

Simulation : A process of CAI that involves copying a realistic situation on the computer.

Software : Includes the programs, computer language, procedures and documentation used in data processing. Generally used to refer to the pre-programmed materiel used to carry out instruction.

Traditional Instruction (TI) : Refers to any non-computer instruction that would be found in the (average) classroom.

Tutorials : Refers to the software developed to help remediate students' difficulties.

User Friendly : The process of making software easier for a operator to run. It is a relative term.

Voice Modem : An adaptable piece of most computers that allows the computer to communicate verbally.

Word Processing : Using a computer to process written data. Using the computer as a type writer.

Purpose of the study!

With the extensive use of computers in today's classrooms a few basic questions have been raised. The goal of this study is to examine, and when possible, answer those three vital questions. The questions are

1. Is the computer an effective educational tool?
2. If so how can it best be implemented into the curriculum?
3. What are the most effective types of software and learning styles to use with computer education?

The study attempts to answer each of these questions by looking at a variety of classroom situations. The study examined classrooms from kindergarten through college level. A variety of classes were examined, ranging from English to math to social studies, as well as other subjects. The goal was to obtain a wide base of knowledge dealing with computers as an educational tool and not to limit the study to a few situations.

Limitations:

The study attempts to limit itself to examining use of the computer for instruction. The use of programming is not the topic here. Programming examples are used rarely. Too often computer education is equated with the teaching of programming, this is a small part of computer instruction (McCorduck and Russell, 1986).

The study focuses on the microcomputer leaving out a large number of educational computers in use today, namely the mainframe computers. There are several reasons for leaving out mainframe computers, i) although the research discusses use of micro computers, most is similar for mainframes and would be a repeat to study their uses. ii) Most educational software is designed for microcomputers, this has resulted in schools getting away from the use of mainframes except for when programming is the emphasis. iii) Mainframes are rare at the elementary and junior high levels, and infrequently found at the high school level. The main use of mainframes is at the college level and the focus of this study (although not the limit) was k-12. iv) Microcomputers are much more effective than mainframes at the elementary level, and slightly more effective at all other levels (Niemic and Walberg, 1987).

The study of how to implement computers into the school is not extensive. Little research has gone into effective computer room set-up. The main publishing on this topic at the present time involves case studies and observations. The discussion of this was limited. It was attempted to give the reader sufficient background information.

I. Background

a. Statistics

W, A.D. "A Status Report On Computers In Schools." Personal Computing Sept. 1985: 88.

Report of the growth of personal computers in the schools grades k-12 with a projected number for the future. The study was conducted by Talmis, a market-data research firm. In the year 1981 there were 127,000 personal computers in schools k-12. By 1985 there were 1,275,000 personal computers in the schools. There is a projection of 4,872,000 personal computers in schools grades k-12 by 1990. The study showed that more affluent communities owned more software. The software in the more affluent communities was of higher level, less drill and practice and more simulation. The most common use at the elementary school level was drill and practice. The most common use at the high school level was programming. There was no mention of the distribution of computers among grade levels or school districts. The article only studied personal computers, it avoided looking at larger mainframe computers.

Barker, Bruce. "The Role Of the Microcomputer In Rural Schools." The Rural Educator 8.1 (1986): 1-3.

The study compared educational computer use of small school versus large school. Small schools were defined by enrollment less than 475 in grades nine through twelve. Large schools had enrollment of over 1000 in grades nine through twelve. Of the schools that were surveyed, 99% had at least one microcomputer. Small schools had an average of 9.8 microcomputers per school. Large schools had an average of 27.2 microcomputers per school. The computer/student ratio was 1:32.2 for small schools and 1:59.1 for large schools. A computer literacy course was taught in 80.3% of the small schools and 82.3% of the large schools. A computer programming course was taught in 75.2% of the small schools and 91.2% of the large schools. In the small schools 20.1% of the teachers classified themselves as computer literate while 36% reported they were not familiar with how to operate a computer. In the large schools 14.5% of the teachers classified themselves as computer literate while 49% reported they did not know how to operate a computer.

The uses of the computers were closely related in large and small schools with the exception of computer programming courses. The most common purpose was instructional use followed closely by management uses. The computers were used most often in computer science courses. The next most frequent use occurred in business courses, generally for data and word processing. In this study no significant difference appeared between computer use in large and small schools.

Reinhold, Fran, and Kay Corket. "Mandates." Electronic Learning Oct. 1985: 25-31.

A survey of state requirements with regards to computer literacy. Twenty-six states had a state-wide policy requiring students to take some form of computer literacy course. Many of the other states requested it at the state level but allowed the local districts to create their own policy. Thirty-six states had a full time coordinator of computer education. Forty-one states had a centralized way of evaluating computer software for the local districts. Twelve states had a certification process for teachers who teach computer courses. All states were involved in in-service training for teachers. States have been involved in computer education but some are hesitant to make state-wide policy.

Arndt, Stephan, James Clevenger, and Lori Meiskey. "Students' Attitudes Toward Computers." Computers and the Social Sciences 1.3/4 (1985): 181-186.

The U.S. Department of Labor predicted that the market for programmers will increase by about 77% from 1982 to 1995. The increase in jobs for systems analysts will increase more than 85% in the same time interval. This study was conducted to assess student attitudes toward computers and to see if these attitudes could be categorized. The sample population consisted of college students. The method was a mail in survey on a large midwestern university. 93% of the students in the study had used a computer before, they averaged two years of computer use. The students overwhelmingly responded that the computer was important for future employment. The students expressed a desire to learn more about computers, even those who responded that the computer was not important for future employment. There were two types of students who responded to the survey. One group was those who had a low regard for the computer. This group tended to feel that society relies too heavily on the computer. They classified the computer as 'bossy', 'dominant', 'impatient', and 'threatening'. Most of this group had no understanding of how a computer works. They felt that the computer would accept spelling errors when programming. This group often had little experience on the computer. There was a positive correlation between computer experience and seeing the computer as a pleasing thing. Those who see the computer as necessary for their future occupation had more experience than those who did not see it as necessary. The study clearly pointed out the fact that more experience and better attitudes are related and little experience and poor attitudes towards computers are related. The study did not attempt to point out which was the independent variable in each situation.

b. Examples

Hoot, James. "Computing in the Soviet Union." The Computing Teacher May 1987: 8-10.

Hoot researched how computers are used in schools in the Soviet Union. In 1984 the USSR adopted a three part national policy encouraging the use of computers. The policy stated that

i) experience in the lower grades is required for all students.
ii) A course on Principles of Information Science and Computing Technology beginning in the 1986 school year.
iii) Secondary classrooms should have 1,000,000 computer in use by the year 1990.

The statistics for Soviet computer use are deceptive because they refer to calculators as computers. In 1986 the average large city school had three to four computers in use. The first Soviet microcomputer available to schools was the Agatha, first out in 1983. The Agatha was a model similar to the 1983 version of the Apple. The cost per school was approximately $5000 per computer. Large networks were non-existent in Soviet schools. Phone modems were impractical because of poor phone line quality. Most educational software was written in a foreign language. Russian language educational software was almost non-existent. Most good Russian software was developed on an individual basis. Most of the programming was done in English or German. Most of the computer programming courses spent little or no time on a computer. Students that were interested in learning about computers joined a computer club. The club was independent of the school and generally met in the evenings. The clubs often were run by businessmen. These clubs had access to foreign produced computers. A sample of a computer club's hardware contained twelve Amstrands, Three Tandy's, two Ataris, and four Commodores. The Soviet schools lag behind the U.S. in computer use. The main reason is lack of good hardware and software.

Dearborn, Donald. "How States Evaluate Software." Electronic Learning Oct. 1985: 27.

The study examined the various methods states used to evaluate software. Educational Products Information Exchange (EPIE), was one of the metods several states used. EPIE is a New York based group whose soul purpose is to evaluate software and raise schools awareness. Other services used included Microsift service, an Oregon based educational think tank. Many states used state-wide recommendation lists and publications. Some states had a standardized form for software evaluation. Much progress has been made in centralization of software evaluation.

Whiting, John. "New Directions in Educational Computing: Coming Changes in Software and Teaching Strategies to Optimize Learning." Educational Technology Sept. 1985: 18-21.

This contained a case study of the state of computing in the United Kingdom with suggestions for future development. In 1984 every school in the United Kingdom had at least one Microcomputer. In the past, the national government has been a great supporter of computing in the schools. The national government has worked at teaching schools how to implement computers. The goal of the government was to select systems such that teachers, students, software and hardware would be compatible. The types of programs observed in the schools included drill and practice, discovery learning, and simulations. The United Kingdom encourages more computer use in the homes. A national policy encourages better teacher training.

Wehrenberg, Stephen. "Training-Is the Computer the Ultimate Tool?" Personnel Journal April 1985: 95-6.

This is a report of a study about how large corporations used computers for employee training. Some of the companies studied included Holiday Inn, Bell Systems, American Airlines, and Honeywell. A questionnaire was administered to identify reasons for use of computers in training. The main reasons given for use of computers was the ability to individualize, and the quality of work. Since companies have employees coming in with various backgrounds, the computer was able to pinpoint areas where extra instruction was needed and focus on those points. Companies reported a second reason for using computers, uniform training could be given to employees without the result of human error in the instruction.

II Effectiveness of CAI
a. student performance

McCorduck, Pamela, and Avery Russel. "From Drill Sergeant to Intellectual Assistant: Computers in Schools." Principal Nov. 1986: 16-20.

The study synthesized several studies on computer usage in the schools, gave a basic history of computers in the schools and predicted needs of the future. A computer-based instruction of writing program sponsored by IBM concluded 90% of first graders were able to read above grade level after completing the IBM program. A college teacher successfully taught college mathematics to a group of seventh graders with the aid of a computer. These results report two things, that a computer is a helpful educational tool and that the software used in each case was very good. Computers were forced into the schools by parents who demanded their children be taught the technology of the future. In 1981-82, 27% of the money used to purchase school computers in the U.S. was raised by parents. In the seventies most computer instruction consisted of programming lessons. Since that time, with the development of better software, the teaching of programming is no longer necessary. In the future there will be a glut of programmers. The goal of the school should be to teach students how to use software. Five areas that students should learn to use a computer include, i) writing, ii) simulations in science, iii) drafting, iv) building trades and v) data searches and analysis in the social sciences. The computer should be applied in all classes but there is no need to teach programming.

Handly, Tom. "CAI in Special Education: Research Directions." Peabody Journal of Education 62.1 (1984): 27-39.

Handly synthesized several reports of the computer's effectiveness as an educational tool. By the spring of 1984 approximately 50% of the classrooms in the U.S. made use of a microcomputer. The ability to individualize lessons was reported as the biggest advantage of using a microcomputer. Visonhaler and Bass (1972) summarized 30 studies to conclude microcomputer assisted instruction(CAI) and traditional instruction(TI) were equally effective. Jamison, Suppes, and Wells (1974) concluded that CAI was an adequate substitute for TI at all levels of instruction. Kulik (1983) found that 81% of the students involved in CAI outperformed the average performance from TI. McDermott and Watkins (1983) found performance of first through sixth graders equivalent using CAI and TI. The conclusion of the synthesis of articles was that CAI and TI had equal results for the situations tested. However, CAI was more effective in certain situations.

Levin, Henry, and Gail Meister. "Is CAI Cost-Effective?" Phi Delta Kappan 67.10 (1986): 745-9.

The research considered the effectiveness of CAI compared to that of, tutoring, increased instructional time, and reduced class size. The goal was to find the most cost effective method of increasing student performance. The study measured the students academic gains reported in months of additional achievement per year of instruction. Achievement was measured in math and reading. The effectiveness rating was taken from previous studies performed by various researchers. The method that produced the greatest achievement was peer tutoring followed by adult tutoring followed by CAI. The study then measured the cost of each mode of learning. Tutoring was the most expensive method used.

The cost effectiveness rating was obtained by dividing the months gained per year of instruction by the cost. This number was multiplied by 100 and reported as the months gained in instruction per $100(MGPH). The most cost effective method in mathematics was peer tutoring rating 4.6 MGPH, followed by reducing class size from 35 to 30 with a rating of 1.4 MGPH. CAI finished third with 1.0 MGPH, adult tutoring .8 MGPH, and increasing instructional time .5 MGPH. In reading peer tutoring also won with 2.2 MGPH followed by CAI with 1.9 MGPH. The conclusion was that CAI was an effective way to educate but not the most effective or cost efficient.

Thinking that the cost of CAI may drastically decrease as computers become more available, a study was performed to find how much the cost could be affected by a decrease in the price of hardware. It was found that hardware cost comes to less than 25% of CAI cost.

Niemiec, Richard P., Madeline Blackwell, and Herbert Walber. "CAI Can Be Doubly Effective." Phi Delta Kappan 67.10 (1986):750-1.

The article refuted the study performed by Levin and Meister on the cost effectiveness of CAI. The study reevaluated the effectiveness of CAI and tutoring. To evaluate CAI, 29 previous studies were synthesized. They found CAI to be much more effective than did Levin and Meister. They also point to other studies on tutoring and find that Levin and Meister overrated the effectiveness of tutoring. Levin and Meister limited their study to one case that was poorly documented. Using Levin and Meister's results for the cost of each they recalculated the cost effectiveness of peer tutoring and CAI. In mathematics they found CAI to have a cost effectiveness of .45 MGPH compared to .29 MGPH for peer tutoring. They found reading to have a rating of .35 MGPH using CAI and .1 MGPH for peer tutoring. The conclusion of Niemiec, Blackwell, and Walberg was that CAI was the most cost effective method for improving instruction.

McCollister, Tonni, Diane Burts, Vernon Wright, and Gladys Hildreth. "Effects of Computer-Assisted Instruction and Teacher Assisted Instruction on Arithmetic Task Achievement Scores of Kindergarten Children." Journal of Educational Research 80.2 (1986): 121-5.

The study reported the difference of CAI and TI on cardinal counting skills. The sample population consisted of kindergarten students. The students were pre-tested and placed in one of three ability levels. Group one had no recognition of numbers 1-10. Group two had recognition of numbers 1-10 but not 11-20. Group three could recognize numbers 1-20. Each level had a control group receiving TI and a experimental group receiving CAI. Every effort was made to make sure that each group received the same instruction. Students in the experimental group were asked to count objects on the computer screen. The students in the control group were asked to count objects on a felt board. Each level had one teacher who taught the control group and the experimental group. The students in group one made more improvement with traditional instruction, while groups two and three made more improvement with CAI. Drill and practice was best performed on the computer, however learning new material was best accomplished through traditional instruction.

Dog, Pete. "Exciting Effects of Logo in An Urban Public School System." Educational Leadership Sept. 1985: 45-7.

Students' performance and attitudes toward computer use were assessed. The sample population consisted of students in grades k-12 in the St. Paul school system. Students would take turns working on a microcomputer while the other students continued TI. The students computer use involved using LOGO to perform tasks. LOGO was selected so that students could do a wide variety of activities without the teacher spending time with them. Approximately ten percent of the students made drastic improvement due to the computer. Approximately 50% made some improvements due to the computer. No correlation was found between the students' improvement and other variables, such as prior performance, social class, and motivation. After having used the computer for a period of one year, the students attitudes reflected that they liked school better and they were more enthusiastic about learning. Rather than the use of a scientific approach when he analyzed the data, Dog merely reported general trends that occured.

Reed, Stephen K. "Effect of Computer Graphics on Improving Estimates to Algebra Word Problems." Journal of Educational Psychology 77.3 (1985): 285-98.

The goal of this study was to find if performance on algebra word problems could be improved through use of computer graphics. The sample population consisted of college undergraduates. Each student was given four word problems. Students were administered a pre-test and post-test to measure improvement. The first story problem involved a *rate times time equals distance* problem. After the pre-test students observed two dots move across the screen to simulate the problem. When no explanation of the problem was given students improved their performance only 8% of the time. When the dots were viewed along with an explanation of what the students were to look at 50% of the students improved on the post-test and 17% did worse. The second problem involved a *work problem*, watching two pipes fill a tank. After watching, students improved their estimates 19% of the time but did worse 23% of the time. No case was done with an explanation of the problem for the students. The last case involved a *mixing problem* with no explanation given. The students showed no significant improvement for that case. Graphics did not improve student performance. Graphics accompanied by an explanation improved student performance.

Niemiec, Richard, and Herbert Walberg. "Comparative Effects of Computer-Assisted Instruction: A Synthesis of Reviews." Journal of Educational Computing Research 3.1 (1987): 19-33.

A synthesis of previous studies on CAI instruction was reported. After looking at a large number of reviews the authors found that much of the computer research that has been done was poor in quality. The problems have consisted of inadequate methods of evaluating scores and assessing performance. The largest problem found was that most studies did not isolate the topic to be studied, too many variables existed. The authors selected a wide variety of studies and analyzed the effects of CAI.

The studies were selected so that they did not have the problems noted above and they were a representative sample of U.S. student population. Studies of kindergarten through college were selected. The majority of studies showed an improvement due to CAI. There were no studies which showed CAI had a negative effect. The improvement was inversely related to grade level of students. Microcomputers were slightly more effective than mainframes at the college level. Microcomputers were extremely more effective than mainframes at the elementary level. CAI had a positive effect on students, but care must be taken in researching CAI

b. Student Attitudes

Perez, Elizabeth, and Mary White. "Student Evaluation of Motivational and Learning Attributes of Microcomputer Software." Journal of Computer Based Instruction 12.2 (1985): 39-43.

The goal of the study was to examine the attitudes students possess concerning using computer software for education. The sample population consisted of sixth grade students from a metropolitan area. Each student was administered one session on the computer and one session of traditional instruction. There were three different types of software administered: games, drill and practice and simulation. Each program was designed to aid in teaching multiplication facts. The students were administered an attitude survey after the lessons. The survey was coded one through ten where ten represented enjoying the activity the most. The mean score for the CAI was 8.57 while the mean score for TI was 7.58. The response for student assessed educational worth was 7.97 for CAI and 7.58 for TI. But further questioning showed that students felt they had learned different things when using the computer compared to TI. Using the computer was a useful method to improve student motivation.

Mevarech, Zemira R., and Yisrael Rich. "Effects of Computer-Assisted Mathematics Instruction on Disadvantaged Pupils' Cognitive and Affective Development." Journal of Educational Research, 79.1 (1985): 5-10.

The study was conducted to compare the effects of CAI and TI. The sample population consisted of students in grades three through five in an Israeli developmental town. The students were split into two groups. The control group received traditional instruction while the experimental group received three parts traditional instruction to one part CAI. No pre-test was administered. The students were split according to previous performance such that each group would have equal ability. A nationally standardized post-test (the Arithmetic Achievement Test) was administered. At each grade level the experimental group out scored the control group. An attitude analysis was done on both groups. After completing CAI students had a higher liking of mathematics, a better self-concept of their math ability, and a better attitude towards school. The study was significant in that it showed that by combining TI and CAI student performance was improved.

Jason, Leonard A., Bart Pillen, and Thomas Olson. "Comp-Tutor: A Computer-Based Preventive Program." The School Counselor Nov. 1986: 116-21.

A tutorial program was designed in which students in grades six through eight used a computer to tutor students in grades one through four. Before each session the tutors would spend twenty minutes preparation time on the computer. This time involved learning how to use a commercially designed piece of software, teacher created software, or in a few cases software designed by the student. The tutors were selected on a volunteer basis. The students in the tutorial program showed increased math achievement scores, improved spelling scores, and higher self-appraisal, but the improvement did not differ significantly from the control group. The tutors and tutees using the computers rated the program as much more enjoyable than those in the control group. The computer had value as a motivational tool.

Diem, Richard A. "Microcomputer Technology in Educational Environments: Three Case Studies." Journal of Educational Research 80.2 (1986): 93-7.

The study involved an observation of three classroom environments: an elementary class, a high school special education class, and a GED adult program. The students were observed weekly throughout the year. The elementary ciass had access to a computer room containing 15 microcomputers. All the students seemed to look forward to weekly time spent in the computer room. Most of the programs used were for drill and practice. The students learned the basics of computer operation, how to load a program, print material, and save files. By the end of the year teachers and students became discouraged with the software, they felt it did not demand a high enough thought process.

In the high school class the students worked mainly on drill and practice programs and word processing. The students made great use of the word processing program. Many students took to writing who never did before. The teachers and students became discouraged with the drill and practice programs. The word processing made the year.

The GED made successful use of the computers. The students were able to individualize their work more than before. Most of the programs used were drill and practice in content. They provided extra motivation since many students felt it would improve their employment opportunities. Many students became discouraged when they discovered that they could not do the things they had hoped on the computer. The key to successful use of computers was good software.

Johnston, Vivien. "Attitudes towards Microcomputers in Learning: 1. Pupils and Software for Language Development." Educational Research 29.1 (1987): 47-55.

The study assessed student attitudes towards computers, then examined differences in attitudes between the sexes. The sample population consisted of high school students in an English class that implemented CAI. The students were administered an attitude questionnaire. Forty-six percent of the students owned their own microcomputer, (61% of the male and 28% of the females). Eighty five percent of the students had prior experience using a microcomputer, (93% of the males, 76% of the females). Most students, 96%, found the computer enjoyable. Only 67% of the students felt the computer could aid them in learning. 74% of the students responded that the computer was more interesting than the teacher, but only 44% felt that the computer was more effective than the teacher. Students with reading difficulties found the computer screen easier to read than a textbook. Students enjoyed the use of CAI.

There were few differences between male and female attitudes toward CAI. The small differences were due to experience. Males had more experience using computers. The only significant difference in male and female use was in how the liked to work on the computer. Females preferred independent work. Males showed a preference for group work. The study showed that student attitudes, both male and female, can be improved by using CAI.

Anderson, Ronald. "Females Surpass Males in Computer Problem Solving: Findings from the Minnesota Computer Literacy Assessment." Journal of Educational Computing Research 3.1 (1987): 39-51.

It has been documented that males outperform females in mathematics achievement. Some studies indicated that this is true in computer work also. The goal of this study was to find if any sex difference existed in computer achievement when no math bias was given to computer work. This is a follow up to the 1982 National Assessment in Science which indicated that junior and senior high females out scored the males in the area of science decision making. The sample population for the study consisted of eighth and eleventh graders from Minnesota public schools. The results indicated that males outperformed females in the area of program reading. Females significantly outperformed males in the area of problem analysis. The most significant variable was computer experience. When math bias is taken away females achievement was as good, or better, than male achievement.

Gressard, Clarice P., and Brenda Loyd. "An Investigation of the Effect of Math Anxiety and Sex on Computer Attitudes." School Science and Mathematics Feb. 1987: 125-35.

The study attempted to find a relationship between computer attitudes and math anxiety. The sample population included junior high through college students. Three computer attitudes were measured: computer anxiety, confidence, and liking. On a pre-test students had a slightly positive attitude towards computers and math. Computer experience was positively correlated to each of those variables. A small negative correlation existed between math anxiety and computer attitudes. The correlation between sex and computer attitudes was statistically insignificant. The study suggested that i) the relationship between math and computers should be down played, ii) students who dislike computers should be encouraged to obtain more experience and iii) there are no differences in attitudes between the sexes.

Lengel, James. "Neither Marx Nor Piaget." Computers in the Social Studies Jan. 1987: 52-3.

A report of the social development of schools that implemented computers into the curriculum. The study was a synthesis of several case studies. The development is broken down to three primary steps. Stage one was called the p-stage (personal stage). The p-stage started with one instructor (usually a male) convincing the school to allow him to purchase a computer. He was the sole operator and manager of the machine. Students and other teachers became motivated to learn about the computer. The school system became aware of students motivation to learn more about computers. The school then decided to move to stage two, the d-stage (diffusion stage). In this stage computers were circulated throughout the school. All teachers were encouraged to use them. Large amounts of money were spent on hardware, but often small amounts spent on the software. Software was poor and teachers became discouraged. They could not revive the spirit that existed in the p-stage. The computers ended up back with the few teachers who became interested during the p-stage. After some analysis of the problems that occurred in the d-stage the t-stage began (tool stage). The computer was recognized as a useful tool. Better software was purchased. Teachers learned to use the computer to help data management, word processing, tutorials and remediation. Computer use was not as wide spread as in the d-stage but the computer was being put to use where it could best be implemented. The t-stage was the final stage of development classified in the schools.

III. Implementation of CAI

Parker, Janet. "A Five Step Process to Help Educators Decide How to Use Computers in Schools." NASSP Bulletin April 1985: 2-8.

A committee studied the most efficient ways of introducing computers into schools. When five steps were followed the schools received more efficient use of computers.

1. A committee was established to study the :
   - A. present equipment,
   - B. the needed equipment, that included
     - i. hardware,
     - ii. software, and
     - iii. logistics.
2. The committee set goals for CAI.
3. The committee reported to the school curriculum guidelines and student objectives.
4. The committee made plans and then implemented:
   - A. staff training,
   - B. software management:
     - i. purchasing software,
     - ii. software storage, and
     - iii. software training.
5. The committee was responsible for periodic evaluation of the program.

By following this five step process teachers were allowed educational freedom and schools had maximum use of computers.

Sedran, Mary. "Technics for Managing a Computer Classroom." Mathematics Teacher April 1985: 262-5.

This case study discussed several classrooms' implementation of CAI and the most effective methods were reported. The most effective classrooms were ones where the hardware was set-up so that students were allowed to work in pairs. The classrooms were set-up so that learning could take place away from the computers but the computers could be easily accessed. Students were assigned seats to avoid rush to the 'good' computers. Student were given plenty of time to shut down computers and store files before the class ended. Student were taught level specific material. They did not need to learn new material from math or English class but applied skills they were familiar with. The study used observation techniques and no attempt was made to make the study appear scientifically researched.

Sales, George. "Design Considerations for Planning a Computer Classroom." Educational Technology May 1985: 7-14.

Analysis of research showed that several principles influenced the successful implementation of a computer room. The successful schools planned ahead. They found the best way to fit the material into the classroom. Moreover, these same schools chose a room with proper size and shape for the systems used. Guerson and Kamp found the minimum work space needed was 70 cm per station. A room with proper power supply including a master switch for the instructor was essential. The rooms had the proper sunlight and capabilities to adapt to different levels of lighting for computer use verses classroom use. The school had the same fixtures as a regular classroom with the exception of a chalkboard. Chalk dust will ruin computers. A phone with a private line was accessible when a phone modem was used. Furniture was selected that fit the students properly. The stations were individually adjusted. The proper size of a work station for adult use had the monitor 82-89 cm. above floor level. The key board 5-10 cm. below the monitor. The students were 45-75 cm. away from the monitor. The students looked down at the computer with an angle of 10°-20°. By following these principles a successful computer room was developed.

Grover, Sonja C. "A Field Study of the Use of Cognitive-Developmental Principles in Microcomputer Design for Young Children." Journal of Educational Research 79.6 (1985):325-31.

This research started with the hypothesis that if care was taken to use cognitive learning principles that were proven effective in TI, the software would be more productive. The learning principles tested were i) cuing, between the keyboard and monitor, ii) use of graphics, iii) matching the students cognitive learning skills to software level, iv) personalizing feedback, and v) using only neutral feedback after errors. The sample population included students from preschool, kindergarten and first grade. The student were separated into four groups, cognitive and non-cognitive, with or without a voice modem. The students were asked to complete some basic counting problems. Cognitive students counted apples falling from a tree while non-cognitive students counted rectangles. The cognitive students were given visual and auditory cues (when a voice modem was used). The cognitive students were given specific feedback while the non-cognitive students were only told if they were correct or incorrect. Two comparisons were made cognitive to non-cognitive and voice to no voice. The cognitive students significantly outperformed the non-cognitive students. The cognitive students had a much better attitude towards the computer. The students without a voice modem outperformed those with a voice modem. Even the non-cognitive group with out a voice modem outperformed the cognitive group with a voice modem. Cognitive principles improved student performance. Voice modems were not effective.

IV Making Software Effective

Vargas, Julie S. "Instructional Design Flaws In Computer-Assisted Instruction." Phi Delta Kappan 67.10 (1986): 738-44.

This is a synthesis of research on principles proven to make CAI effective. Computer activities were divided into four categories i) drill and practice, ii) simulations, iii) tutorial and iv) tools. Programs that involved students reading and writing were more effective than programs presented as lectures. The programs with immediate feedback were more beneficial than those with no feedback or delayed feedback. When some guidance of time was used in the program it was more effective than a self-paced program. Programs broken into smaller subprograms were more effective than those which presented all the material in one unit. User- friendly programs were more effective than non-user friendly lessons. Graphics were only advantageous when they had specific purpose and could be presented quickly. Programs that were tested before implementation were generally better than others. The most effective programs were those which followed educational principals proven effective in TI.

Isaacs, G. "Test Screen Design for Computer-Assisted Learning." British Journal of Educational Technology 18.1 (1987): 41-51.

This study is a synthesis of research on the most effective screen design for a CAI lesson. Heines (1984) reported four key factors of screen design: type style, line length, justification, and break points. Type that included all upper case was less legible (Tinker 1963). Special features of type used in CAI included underlining, blinking information, *italics,* and color. Underlining did highlight material but made the next line harder to read. Italics were effective but not available on most computers. In every case students focused on blinking information. There should not be more than one blinking piece of material on the screen at any given time. Color was a very effective way of drawing attention to specific words.

Shorter lines were easier for students to read (Heines 1984). Feedback was most effective when highlighted in some way to bring attention to itself. With some care in design of a computer screen a CAI lesson can be improved.

Levin, Barbara. "A Dozen Ways to Put Your Classroom Computer to Work ... At Last." Curriculum Review Sept./Oct. 1985: 40-3.

This is a synthesis of case studies. Levin presents ways found to use the computer effectively. Those twelve ways were:

1. Chain learning-Levin taught one student and had them pass on the knowledge to the next student.
2. Individualized feedback,
3. Cooperative learning,
4. Discovery learning,
5. Teams and tournaments,
6. Drill and Practice,
7. Generate classroom materials,
8. Brainstorm and problem solving,
9. Students evaluated software
10. Use of tree story writing,
11. Data base information collected and interpreted, and
12. Students learned keyboarding skills.

Each of these ways were observed in a classroom situation. Each were implemented effectively. They give a few of the uses of computers in the school.

Schloss, Cynthia, Patrick Schloss, and Phillip Cartwright. "Placement of Questions and Highlights as a Variable Influencing the Effectiveness of Computer Assisted Instruction." Journal for Computer Based Instruction 12.4 (1985): 97-100.

The use of questions and highlights in CAI was studied. The sample population consisted of college aged students. The students were administered a concept test, a mastery test and an attitude survey. The students were asked to work on CAI lessons. The students were split into two large groups. One group's CAI contained questions and the other group's contained highlights. Both groups were split into smaller groups. The smaller groups varied in the number of questions or highlights received. The groups received the following ratios of screens to highlights (or questions), 1:1, 3:3, 5:5, 90:90, 90:0. If the student made an incorrect response on a question they had a second chance. If the second time a incorrect response was recorded, the correct response would be given to them. The results of the concept test showed that students learned more concepts with highlights. The best performance came from students receiving five pages to five highlights. On the objective test students receiving questions outperformed those receiving highlights. The best score came from those receiving three screens to three questions. The students performed lowest in both cases that received 90:0, followed by those who received 90:90. On the attitude survey students preferred highlights to questions with the exception of 1:1 case. Students reported that they least liked the 90 screens to 90 questions presentation. Students preferred 90 screens to 90 highlights. The results indicated that including some form of review, either in questions or highlights improves student performance. In lessons that taught new topics highlights are more beneficial and preferred. In lessons that practiced basic skills questions were more effective.

Carrier, Carol A., Gayle V Davidson, Michael D. Williams, and Carrie M. Kalweit, "Instructional Options and Encouragement Effects in a Microcomputer Delivered Concept Lesson." Journal of Educational Research 79.4 (1986):222-9.

The purpose of the study was to identify if added encouragement to see extensive feedback would cause students to chose the extensive feedback. The sample population consisted of sixth grade students. The encouraging statements were intended to be similar to statements a teacher would use in the classroom. As students worked through the lesson three different groups developed. One group chose to see feedback nearly every time possible. Another group almost never chose to see feedback. A third group chose to see feedback most every time early in the lesson but their requests became more infrequent as the lesson progressed. Students were allowed to select one of five options when they completed a section of the lesson. The feedback they choose from: i) paraphrased definitions, ii) additional expository instances, iii) additional practice instances, iv) analytical feedback, v) move on. Students were most likely to select to select feedback i) paraphrased definitions. The students who were given encouragement to select feedback were more likely to select feedback. Students selected feedback less frequently the last half of the lesson.

Merill, John. "Levels of Questioning and Forms of Feedback: Instructional Factors in Courseware Design." Journal of Computer-Based Instruction 14.1 (1987): 18-22.

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The goal of the research was to find if higher level questions affected student performance and if specific feedback affected student performance. The sample population consisted of high school science students. The students were put into four groups. Group one was given high order questions, non-specific feedback in a CAI lesson. Group two's lesson was the same except it contained low level questions. Group three was given high level questions, and specific feedback. Group four was given high level questions and non-specific feedback. Each group was administered a post-test and then the same post-test one week later. The groups receiving high level questions outscored those receiving low level questions on both tests. There was no statistically significant difference between those students receiving specific feedback and those receiving non-specific feedback. The study indicated that the questioning process is important in CAI, and feedback only need be given to help students find correct and incorrect responses.

Ross, Steven M., Deborah McCormick, Nancy Krisak, and Padma Anand. "Personalizing Context in Teaching Mathematical Concepts: Teacher-Managed and Computer Assisted Models." Educational Communication and Technology Fall 1985: 169-78.

Two studies were performed to find if students performed better on CAI lessons when the content was personalized. The sample population for the first study was made up of students enrolled in a college statistics course and majoring in education or nursing. The students were divided into two groups. One group completed a lesson that gave statistical examples related to teaching. The second group completed a lesson that included examples from the medical field. The teachers outperformed the nurses in group one while the nurses outperformed the teachers in group two. The student who were completing material related to their field reported that their lessons were shorter and that they had learned more. This indicates that CAI was most effective when it included material related to the students field of study.

A second study was performed on fifth and sixth grade students. The students were asked to complete a questionnaire of their name, birthday, friends, favorite foods, and hobbies. Students were then separated into a control group receiving a traditional CAI lesson and an experimental group receiving a personalized CAI lesson. Students in the experimental group had the names of their friends, their birthdays and other personalized responses in word problems and examples. The groups were administered a post-test. Students in the experimental group outperformed the control group in problem solving, memory work, and they had better attitudes toward the lesson. Personalization of lessons improved students learning and attitudes.

Belland, John C., William D. Taylor, James Canelos, Francis Dwyer, Patti Baker. "Is the Self-Paced Instructional Program, Via Microcomputer-Based Instruction, the Most Effective Method of Addressing Individual Learning Differences?" Educational Com. and Technology Fall 1985:185-98.

The hypothesis of this study was that students given some guidance in their work could out perform those allowed to work at their own pace. The sample population consisted of college freshman. Students were administered a CAI lesson. One group of students was allowed to work at its own pace. Another group worked at a pace considered correct for an average student. Other groups were given a pace that was to fast or to slow for their level. Students were administered a battery of post-tests so that many modes of learning could be measured. Students given the average pace out scored all other groups. Self-paced groups outperformed the groups with the incorrect pace, but by a small amount.

Students in the paced group finished the lesson in an average time of 44.64 minutes while students who paced themselves took an average of 50.36 minutes to complete the lesson. In all groups when students gave an incorrect response for questions they were allowed to review feedback. Low achieving students chose to see feedback only 29.72% of the time while high achievers selected feedback 86.56%. The study supported the hypothesis, students did not know when to receive feedback or at what pace they should have worked.

Johnson, Roger T., David W. Johnson, and Mary Beth Stanne. "Effects of Cooperative, Competitive, and Individualistic Goal Structures on Computer-Assisted Instruction." Journal of Educational Psychology 77.6 (1985):668-77.

The study was instituted to identify which groups of students performed best on CAI, individual groups, cooperative groups or competitive groups. The sample population consisted of eighth grade students. Modes to be measured included problem solving, attitudes, and social relations. The students were divided into three groups. Each group received the same CAI program and worksheets. It took ten days to complete the lesson. One group worked individually, another group was competitive in nature, and a third group where students worked cooperatively. Students in the cooperative setting completed more worksheet items and had more of them correct. Their performance was followed by individual workers and competitive workers, respectively. The students in the cooperative setting directed only 1% of their statements to the teacher while competitive students had 19% directed at the teacher. Students in cooperative conditions indicated higher goal orientation and tended to have more persistence on a lesson. Observations showed that girls were reluctant to take part in the competitive groups. Final analysis showed that students in the cooperative group did more work, as well as better work, and performed better on tests. The cooperative group also had better attitudes toward learning and better self-image towards learning.

Carrier, Carol A., and Gregory C. Sales. "Pair Versus Individual Work on the Acquisition of Concepts in a Computer-Based Instructional Lesson." Journal of Computer-Based Instruction 14.1 (1987): 11-7.

The study was performed to identify if CAI was more suited for individual or pair work. The sample population was made of college juniors at the University of Minnesota. The sample population was divided into two groups. One group received a CAI lesson that they completed individually, while a second group completed the same lesson with the students working in pairs. The students performance was measured four ways. Two post-tests were administered, one directly after the lesson and a second, one week after the lesson. The time it took to complete each lesson was measured. The discussions of the groups were recorded and analyzed. Students working in pairs scored slightly better on the immediate post-test. The delayed post-test showed that pair workers did **not** score significantly better than individual workers. The students working in pairs took less time to complete the lessons than did individuals, 1737 seconds for individuals compared to 1264 for pairs. The performances indicated that with the exception of time pair work did not improve the performance.

Analyzing the recorded discussions students had as they worked in pairs showed which groups worked most efficiently. Female-female pairs verbalized the most as they worked through the lessons. Male-male pairs verbalized the least through the lessons. Female-male pairs spent the most off task discussion time.

Discussions:

In many situations the computer has proven itself to be a useful educational tool. In a synthesis of a variety of studies Handly found that in grades one through six the use of CAI improved students performance over TI. McCollister, Burts, Wright, and Hildreth concluded that use of CAI improved kindergarten performance when used to practice previously acquired skills, but was less effective than TI in teaching new skills. Levin and Meister found CAI to be an effective method of improving student performance but found it less effective and less cost-efficient than peer tutoring. In disputting Levin and Meister's work, Niemic, Blackwell, and Walberg synthesized several studies and found that CAI was more effective and cost efficient than a variety of methods of education, including peer tutoring. Dog found that allowing students to work on programming projects in LOGO improved students performance in grades k-12. Reed concluded using computer graphics helped improve students' performance as long as an explanation accompanied the graphics. Maverech and Rich found the CAI improved math achievement scores over TI in grades 3-5. Niemic in a synthesis of reviews found that in grades k-12 CAI was always equal or better than TI instruction, this included a variety of studies and situations. CAI is equal to or more effective than TI.

The computer has influenced students' attitudes towards, school, learning, and themselves. Dog reports that after a years use of CAI in the classroom, students had a better liking of school. Diem observed elementary, high school and GED students and found their motivation to be improved with the use of CAI. Mevarech and Rich

found that underprivileged students in grades three through five improved their, liking of math, attitude towards school, and self-concept, through use of CAI. Perez and White found that sixth grade students felt they had learned more and felt they had done better work when CAI was used. Research performed by Arndt, Clevenger, and Meiskey indicated the more computer experience a student had, the more likely they were to like computers. Johnston found that high school students found the computer more interesting than the teacher, although they felt it was less effective. Johnston also found that there is no difference between male and female attitudes towards computers. Gressard and Loyd determined there is a relationship between math anxiety and computer liking. Anderson concluded that females performed better than males in some forms of computer use. Jason, Pillen, and Olson found that the computer was an effective motivational tool. The use of CAI has had a great influence on students' feeling and attitudes.

Schools should be careful in the implementation of computers into the classrooms. Parker found that before hardware is purchased a committee should be formed to study needs, set goals, and carry out the school's plan. Schools undergo stages in their development of computer use, this was an observation made by Lengel. There are many situations in which the computer has successfully been integrated in the schools, the situations involved both management uses and educational uses. Some educational uses included drill and practice programs, simulations, tutorials, word processing, drawing (drafting), and data searches. These are a *few examples* of how the computer has been used effectively in the school.

Care should be taken to design an efficient computer room. Sedran suggested that the room should have the proper equipment, be similar to a regular classroom except no chalkboard since chalk dust can ruin a computer. Sedran also found that computers should be set apart from other classroom learning situations. In a study by Sales, students needed at least 70 cm. per station to work efficiently. Stations should be designed to encourage group work. He also found that equipment should be fitted for the size of users.

The bulk of the research that has been completed with respect to CAI has focused on finding methods of maximizing the success of CAI. Grover concluded CAI was improved when the same cognitive learning skills that have been proven effective in TI were used in CAI. Grover examined a few of those cognitive learning skills including cuing, personalized work, and neutralized feedback. Vargas proved that the use of user-friendly programs improved CAI performance. A few of the things Vargas found that made a program user-friendly were providing immediate feedback and personalizing the lesson. Grover proved that the use of a voice modem decreased students' performance. Isaacs found that special features are useful in highlighting information, the most effective was flashing statements. Moreover, he also found CAI that used short lines in the text was easier for students to read. Schloss, Schloss, and Cartwright found that frequent use of questions and highlights within a CAI lesson helped improve student performance. Questions were better for CAI focusing on practice, while highlights were more effective with CAI that taught new material. Merill's research indicated that higher level questions improved student un-

derstanding over lower level questions. Carrier Davidson, Williams, and Kalweit found that the use of encouraging statements within a program causes students to select feedback more often. Students prefered short statements as feedback over long explanations. Merill concluded that the level of feedback did not affect the student performance. Ross, McCormick, Krisak, and Anand proved that upper level students learned more from material that is specific to their interests or occupations, while elementary students improved their performance by having personalized questions and examples. Belland, Taylor, Canelos, Dwyer, and Baker found that students who were given an internal pacing outperformed those who were self-paced.

CAI is suited for cooperative work. Johnson, Johnson, and Stanne found performance to be maximized when students worked in pairs. Carrier and Sales found that students completed their work in less time when they worked in pairs. Both studies found that individual and competitive work was less effective than pair work.

Conclusions:

'Is the computer an effective educational tool?' Research has clearly shown that the use of CAI is an effective way to educate. There is still much debate on how effective CAI is compared to TI. The computer has yielded tremendous results in some situations and poor results in others. The same is true with TI. The computer appears to be a neutral educator. The use of computer hardware does not make a program succeed. The effectiveness of CAI is dependent on the quality of software used and the teacher's ability to implement it effectively.

The use of CAI has improved students' attitudes towards learning, school, and self. Students using CAI have been found to be more motivated and enjoy their work more than students using TI. Educational biases observed in TI do not effect CAI. There was no correlation between achievement during CAI and social class, also, there was no correlation between CAI and prior performance. There was no difference in male and female achievement during CAI. The computer has proven itself to be an effective motivational tool. It is not clear if the added motivation is something intrinsic in the computer or if it is due to the *Hawthorne* effect.

Computers have been used effectively for tutorials, drill and practice, word processing, data searches, and many other situations. Schools should not limit themselves to thinking that computer education involves teaching programming. Programming is a small portion of computer education. Schools have successfully implemented a computer education program without ever teaching programming.

Little research has been done on how to set-up an effective computer room. Some observations and case studies have found that there are some specific needs in a computer room.

The principles that are effective in TI tend to be effective for CAI. Research has shown that:

i) students work better in pairs,

ii) they need specific feedback,

iii) frequent questioning improves performance,

iv) personalized lessons yield better performance, and

v) moderate pacing improves performance.

The computer is a neutral tool in education. The computer will increase students' motivation. The effectiveness of CAI can be improved by carefully planning the implementation of computers into schools. Carefully selecting educationally sound software will help maximize the effects of CAI. CAI is improved when the teacher uses educational principles proven effective in implementing the software.

Recommendations:

1. More quality research should be done on the effects of CAI.
2. More quality research should be done on successfully implementing a computer education program into the schools. Until sufficient research is done schools should follow case studies that have been observed effective.
3. Schools need to carefully select, purchase, and use educationally sound software.
4. Better software needs to be developed for educational purposes. The software needs to follow educationally sound principles.

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